Vol. 40 No. 3

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MARCH 1913

Development of the peristome in Ceratodon purpureus

ALEXANDER W. EVANS AND HENRY D. HOOKER, JR.

INTRODUCTORY

In his recent work on the Bryophyta, Cavers ('11, p. 182) divides the Bryales, or true mosses, into the four following groups, based on distinctions emphasized by Fleischer: Tetraphidales, Polytrichales, Buxbaumiales, and Eu-Bryales. In this division the peristome is the organ from which the most important differential characters are derived. In the Tetraphidales and Polytrichales the teeth of the peristome are composed of entire cells; in the Buxbaumiales and Eu-Bryales they are composed of thickened cell walls. Leaving the Encalyptaceae out of consideration, the Eu-Bryales may be further divided, following the example of Philibert ('84, p. 67), into the Diplolepideae and the Haplolepideae. The Diplolepideae with few exceptions have two peristomes, while the Haplolepideae have single peristomes, if such structures are present at all.

In the Diplolepideae the two peristomes are derived from two concentric layers of cells in the opercular portion of the capsule. The development of the peristome has been described in several species of this group but is especially well known in *Funaria hygrometrica* (Goebel, '87, p. 188; Campbell, '05, p. 211) and *Mnium hornum* (Strasburger, '02, p. 491), which may be considered typical representatives. In both these species the outer peristomial layer is composed of thirty-two longitudinal rows of cells and the inner of sixteen rows. These rows form sixteen groups,

[The BULLETIN for February 1913 (40: 43–96) was issued March 18.]

each of which in cross section shows two cells of the outer layer lying opposite one cell of the inner layer. One of the sixteen teeth of the outer peristome arises in each group and is formed by the deposition of longitudinal bands of thickening upon the periclinal walls between the peristomial layers. These bands taper to fine points from a broader base. The band deposited by the two outer rows is of fairly uniform thickness throughout and extends as a continuous layer across the thin radial and transverse walls separating the cells. The band deposited by the single inner row corresponds in position and in width with the one just described and is of about the same thickness. Thickening is deposited also upon the transverse walls separating the cells of this row. Upon the disappearance of the portions of the walls which have remained thin the teeth show their mature condition. Each tooth bears upon its inner surface a series of transverse ridges corresponding to the thickened transverse walls, while the smooth outer surface shows the vestiges of the transverse and radial walls, the latter appearing as a zigzag median line running the entire length of the tooth. The delicate inner peristome is formed by deposits of thickening upon the inner walls of the inner peristomial layer. Toward the base the thickening is continuous, but in the upper part it is in the form of isolated longitudinal bands, definite in position and in number. At maturity the continuous portion forms the basilar membrane of the peristome, while the isolated bands form the segments and the cilia.

In the Haplolepideae the peristome is likewise derived from two concentric layers of cells, but in this case each tooth is formed by one row of outer cells and two rows of inner cells and therefore shows the zigzag longitudinal line on the inner surface instead of on the outer. In the opinion of Philibert ('88, p. 68), the single peristome of this group is homologous with the inner peristome of the Diplolepideae. This being the case it is evident that the large-celled inner peristomial layer in the Diplolepideae would be homologous with the large-celled outer layer in the Haplolepideae. The subject of the present study, *Ceratodon purpureus*, is a characteristic member of the Haplolepideae, and many of the features which the peristome shows, in development as well as in structure, are undoubtedly common to other species of the group.

The material, which was collected in the vicinity of New Haven, Connecticut, was studied by means of microtome sections.

The mature peristome of *Ceratodon purpureus* has been repeatedly described in taxonomic treatises, but a brief account of its peculiarities will make the description of the development more intelligible. It consists of sixteen teeth which arise from a continuous basilar membrane. Each tooth is divided almost to the base into two slender tapering branches, which show much the same structure throughout their entire length (FIG. 17, 18). The outer portion of each branch forms a subcylindrical ridge, distinctly contracted at its union with the inner portion, which is broader and more flattened toward the base. Four or five corresponding transverse ridges extend across the branches of each tooth, being close together at the base but farther apart toward the apex. They correspond with the transverse walls of the outer peristomial layer. On the inner surface also vestiges of transverse walls can be detected, but these are unaccompanied by ridges (FIG. 19, 24). Just above the basal undivided portion of each tooth one or more of the transverse ridges extend across from branch to branch, thus leaving median perforations (FIG. 21). The basal portion is especially thick and bears several crowded transverse ridges, which in longitudinal section give the tooth a serrated appearance (FIG. 24). The entire surface of the teeth is covered over with minute spicules. The basilar membrane of the peristome is in the form of a hollow cylinder, sixteen cells in circumference and three or four cells high, representing a part of the outer peristomial layer. The thickened walls in this portion of the peristome are smooth throughout.

The early development of the sporophyte in *Ceratodon purpureus* was studied by Kienitz-Gerloff ('78, p. 42), who detected in very young stages a two-sided apical cell cutting off two rows of segments, just as in other members of the Eu-Bryales. Each of these segments, as he further showed, soon became divided into quadrants by an anticlinal wall and then underwent divisions according to the so-called "Grundquadrat" or "fundamental square" method described below. The embryonic development of *Ceratodon* is discussed also by Goebel ('87, p. 178), but the most complete account of the process is that published by Kuntzen ('12), who, however, pays but little attention to the peristome.

The first developmental study of the peristome in *Ceratodon purpureus* was made by Lantzius-Beninga ('50, p. 574), who compared it with the peristome of *Trichostomum tortile*, now known as *Ditrichum tortile*. In his figures of young transverse sections ('50, *pl. 66, f. 40, 41*) he indicated the two layers of cells which give rise to the peristome but represented each layer as being composed of sixteen cells, those of the inner layer alternating with those of the outer. This was proved to be incorrect by Kienitz-Gerloff ('78, p. 44), who stated that, while the outer layer showed sixteen cells in section, the inner showed from twenty to twenty-four cells and that normally two cells of the outer layer bounded three cells of the inner. He showed further that the peristome developed in the amphithecial portion of the sporophyte and that the peristomial cells represented the fourth and fifth layers from the outside except in the region of the operculum, where they represented the third and fourth layers. The studies of Lantzius-Beninga and Kienitz-Gerloff have to do mainly with the region where the peristome is formed and give but few details about the actual development of the teeth, and the same thing is true of most of the work which has been done upon the peristomes of other Haplolepideae.

In the present paper the account of the peristome will be divided into two parts. In the first the origin and development of the two peristomial layers will be described; in the second the deposition of the thickenings which constitute the bulk of the teeth will be considered.

DEVELOPMENT OF THE PERISTOMIAL LAYERS

As earlier writers have pointed out, the divisions which take place in the segments cut off from the apical cell of the young sporophyte proceed with great regularity, whether the segment is destined to form a part of the stalk or of one of the regions of the capsule. This regularity is characteristic not only of an individual species of the Bryales but of the group taken as a whole. It has been recently emphasized by Kuntzen ('12) in the particular case of *Ceratodon purpureus* and becomes strikingly evident through the study of the operculum and peristome. The opercular segments, like those which go to form the spore-case, are in

the form of half-cylinders, which become divided into quadrants by anticlinal walls. Cross sections through young sporophytes just below the apical cell show this condition clearly (FIG. 1, 2). It is in the quadrants that the division takes place according to the "fundamental square" method. If transverse walls are left out of consideration each quadrant divides by an anticlinal wall, extending as a curved surface from one of the side walls to the outside wall, into two cells (FIG. 3), a smaller triangular cell (as seen in section) and a larger four-sided cell. The latter soon divides by a periclinal wall into an outer and an inner cell (FIG. 4). According to Kuntzen ('12, p. 19) the segments in the stalk sometimes divide in the way just described and sometimes by means of a periclinal wall followed by an anticlinal wall in the outer of the two cells thus formed. In the spore-case he finds the second method only but admits that perhaps the first method is sometimes followed. In either case, after the rearrangement of the walls, the cross section shows four inner cells, the "fundamental square," surrounded by eight outer cells. The inner cells constitute the endothecium and the outer cells the amphithecium. A similar arrangement of the cells can be demonstrated in the young sporophytes of most of the higher bryophytes.

In the next stage of development the amphithecial cells divide by periclinal walls, thus giving rise to two layers of eight cells each (FIG. 5). The inner cells, shaded in the figure, will develop into the inner peristomial layer. The corresponding layer in the spore-case gives rise to the outer spore-sac. It is upon the periclinal walls separating the two amphithecial layers that the teeth of the future peristome will be deposited. Marked differences occur in the endothecium and amphithecium with respect to the relative rate of cell division. In the region of the annulus the inner peristomial layer completes its divisions before the endothecium has passed beyond the four-celled stage. In the region of the peristomial teeth the division may be simultaneous or the endothecium may divide first. In the portion of the operculum above the peristome the inner amphithecial layer never passes beyond the eight-celled stage.

In the region of the teeth, after the stage shown in FIG. 5, the cells of the outer amphithecial layer divide by anticlinal walls,

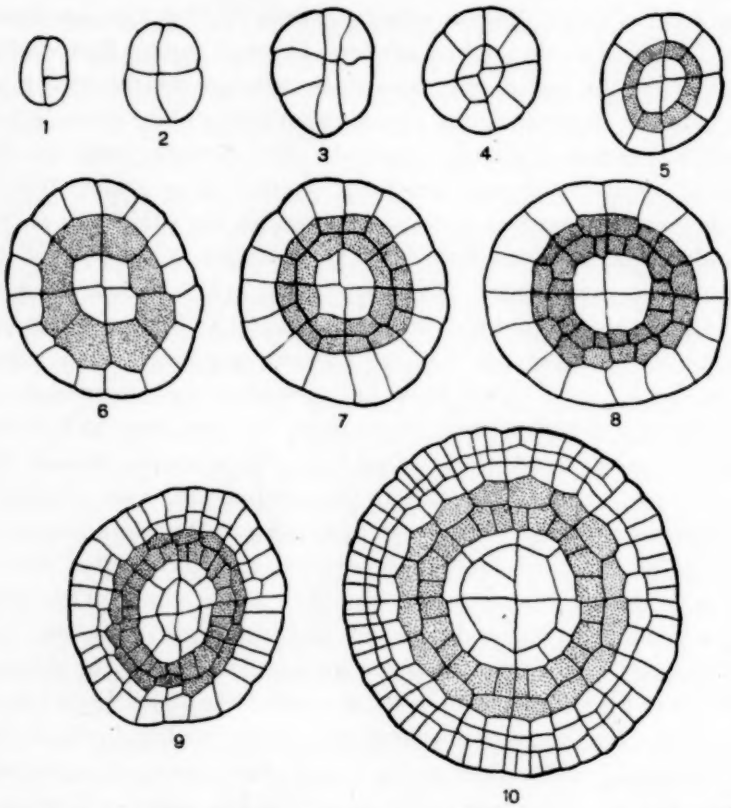

FIG. 1–10. Cross sections through the opercular region of young capsules, showing successive stages of development; peristomial layers stippled, ×300. 1 and 2, division of segments into quadrants; 3 and 4, establishment of amphithecium and endothecium; 5, establishment of inner peristomial layer; 6, division of cells in outer amphithecial layer by anticlinal walls; 7, establishment of outer peristomial layer; 8 and 9, division of cells in inner peristomial layer by anticlinal walls; 10, continuation of divisions in outer amphithecial layer and in endothecium.

thus raising the number of cells in this layer to sixteen (FIG. 6). Each of the sixteen cells then divides by a periclinal wall so that two layers of sixteen cells each are formed (FIG. 7). The inner layer represents the outer peristomial layer and undergoes no further divisions. It will be noted that the eight pairs of cells in this layer lie opposite the eight cells of the inner peristomial layer. In the spore-case the layer homologous with the outer peristomial layer gives rise to most of the photosynthetic tissue

including the large intercellular space. The condition shown in FIG. 7 corresponds closely with figures by Kienitz-Gerloff ('78, *pl. 1, f. 25b*) and Kuntzen ('12, *f. 10*), representing sections through the spore-case. The eight cells of the inner peristomial layer now proceed to divide in a very peculiar way. In each of these cells an anticlinal wall appears (FIG. 8), cutting off either to the right or left a small cell from one fourth to one third as wide as the parent cell. This is followed by a second anticlinal wall cutting off a similar small cell on the other side of the parent cell (FIG. 9). In this way the inner layer becomes divided into twenty-four cells, each group of three corresponding with one of the pairs of cells in the outer layer. No further divisions are undergone by these twenty-four cells. The arrangement of cells just described seems to be even more constant than Kienitz-Gerloff implies, since he states that the number of cells in the inner layer may vary from twenty to twenty-four.

The endothecium and the peripheral layer of the amphithecium play no direct part in the development of the peristome, and yet an account of the cell divisions that take place in them will not be wholly out of place. The divisions in the peripheral layer are not altogether definite. After the sixteen-celled stage, still shown in FIG. 8, the cells divide by anticlinal and periclinal walls without following a rigid system, adjacent cells often dividing in different ways (FIG. 10). In all cases, however, the final condition is essentially the same, three concentric layers of cells being produced. The outermost layer is composed of (approximately) 128 cells, the middle layer of 64 cells, and the innermost of 32 cells. In the region of the annulus, however, only two layers of cells are formed, thus allowing for the extraordinary development of the annular cells (FIG. 13, 25, 26). The peripheral layers of cells form the operculum, the external walls of the outermost layer becoming strongly thickened.

The divisions in the endothecium of the opercular region are essentially like those in the spore-case, as described and figured by Kuntzen ('12). After the four-celled stage, shown in FIG. 8, division takes place according to the "fundamental square" method, eight outer cells and four inner cells being thus formed (FIG. 9). The inner cells repeat this method of division (FIG. 10),

while the cells of the outer layer divide by anticlinal walls in a more or less indefinite manner. When the capsule approaches maturity the endothecial tissue within the peristome consists of a relatively small number of large and thin-walled cells, this tissue of course being the continuation of the columella and the sporogenous tissue in the spore-case.

While the segments have been undergoing the anticlinal and periclinal divisions just described, divisions by transverse walls have also occurred in the various layers. Apparently they occur in a rather indefinite way and vary in different parts of the capsule (see Kuntzen, '12, p. 22, etc.). In the peristomial layers transverse walls are especially numerous toward the base and tend, in this region at least, to be more numerous in the outer layer than in the inner (FIG. 13). Toward the apex they are more numerous in the inner layer (FIG. 12).

DEPOSITION OF THE PERISTOMIAL THICKENINGS

The forty rows of cells taking part in the formation of the peristome may be naturally divided into eight groups of five rows each. In each group three rows of the inner peristomial layer correspond with two rows of the outer layer. A cross section of such a group before the deposition of thickening is shown in FIG. 11. A group gives rise to two teeth of the peristome and the same processes are repeated in each group. The peristomial cells, before the thickenings are laid down, contain dense cytoplasm and small nuclei with several nucleoli but are usually without vacuoles (FIG. 11–13). In the upper part of the peristome, where the teeth are divided into branches, eight regions of thickening can be distinguished in each group, the four of the outer layer corresponding with the four of the inner layer. Two regions belong to each cell of the outer layer and to the median cell of the inner layer, while one region belongs to each lateral cell of the inner layer. The thickening first makes its appearance in the inner layer (FIG. 14) but soon becomes evident in the outer layer as well (FIG. 15, 16). If two corresponding regions are regarded as forming a single strand, each group will then form four strands, representing the four branches of the two peristomial teeth.

The deposition of thickening begins in the basal portion of

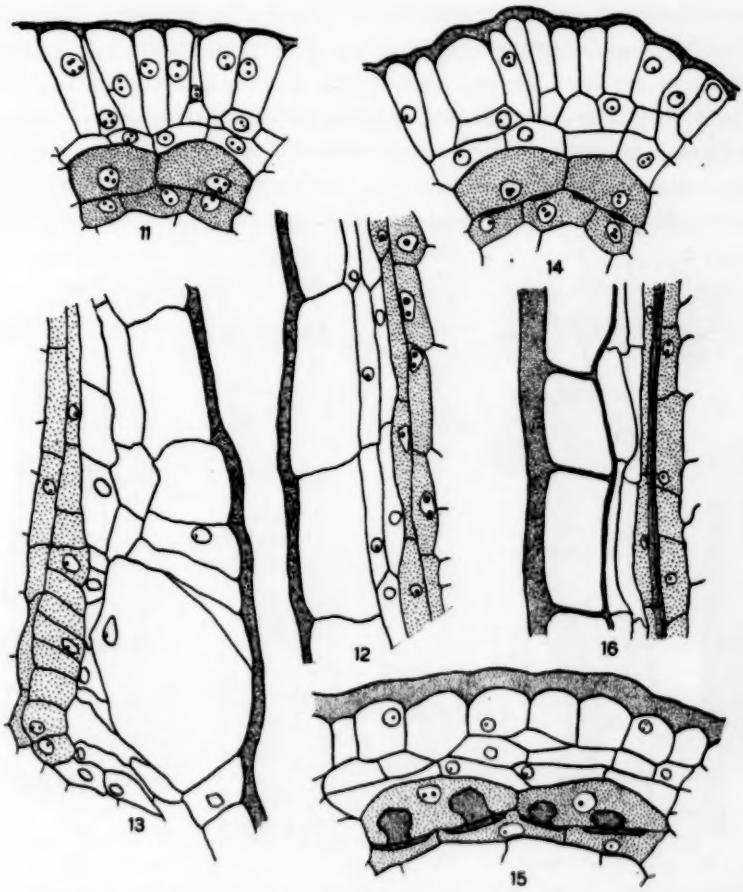

FIG. 11–16. Cross and radial sections through the amphithecial tissues of older capsules, ×300. 11 and 12, showing the peristomial layers in the region of the teeth, just before the deposition of the thickenings; 13, showing the same stage in the annular region; 14–16, showing early stages in the development of the thickenings.

the peristome but follows essentially the same method throughout the branches of the teeth. The portions of the strands deposited by the inner peristomial cells are broader than those deposited by the outer cells. They are therefore more conspicuous at first, but become less so later on. This is due to the fact that the inner portions of the strands develop to a slighter extent and in thickness only, while the outer portions give rise to the thick

subcylindrical ridges already noted in the mature teeth (FIG. 17). The differences between the inner and outer portions become less and less marked toward the apices of the branches (FIG. 18). Upon the transverse walls in the outer peristomial layer thickenings are also deposited. These are continuous with the thickenings on the inner wall and give rise to the transverse ridges of the mature teeth (FIG. 19). In a young stage, seen in tangential section (FIG. 20), the transverse thickenings apparently broaden out the outer longitudinal ridges, and the same appearance is even more

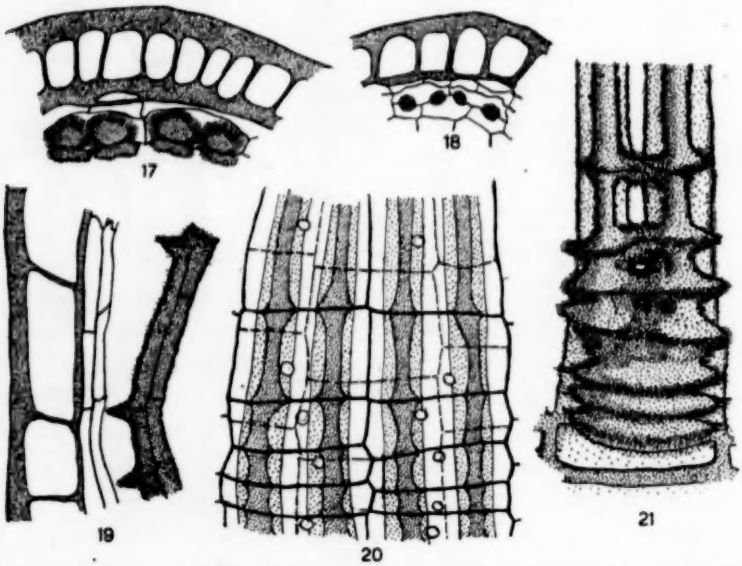

FIG. 17–19. Cross and radial sections in the region of the teeth, showing the peristomial thickenings in their final stage of development, ×300; 20, tangential view of young peristome, seen from the outside, ×300; 21, basal portion of a fully developed tooth, seen from the outside, ×300.

striking in an older tooth (FIG. 21). Toward the base of the branches the transverse ridges grow wider and wider until finally some of them span the distance between the branches and coalesce, thus forming a continuous ridge across the entire tooth. Below this region the ridges are all continuous. If Philibert's ideas regarding the homologies of the peristomial layers are accepted, it becomes evident that the transverse ridges just described correspond with those present on the inner surface of the outer peristome in the Diplolepideae. In *Ceratodon purpureus*, however, the

ridges become adherent to the inner walls of the peristomial layer instead of to the outer walls, as is the case in the Diplolepideae. In the lower part of a tooth the longitudinal ridges on the outside also show an increase in thickness until they extend more than half way across the cavities of the cells in which they are deposited (FIG. 22, on left). In the basal undivided portion of a tooth these ridges finally coalesce and form a single broad ridge (FIG. 22,

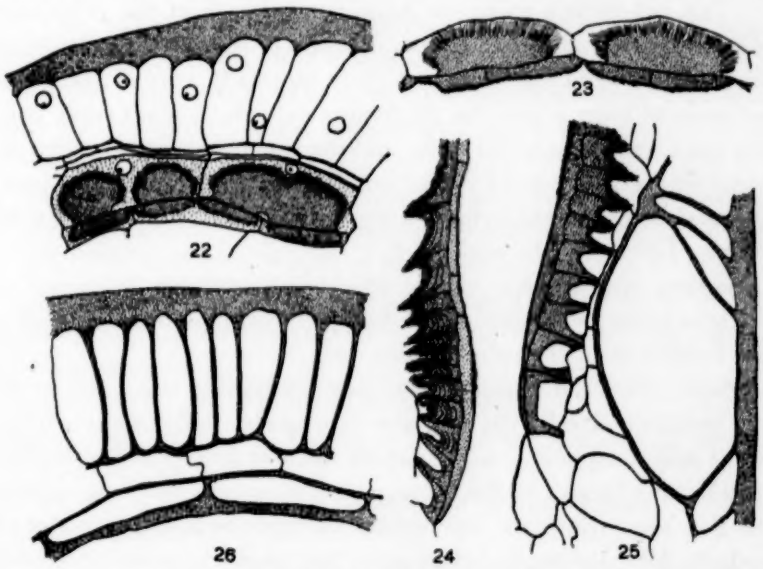

FIG. 22–26. Cross and radial sections in the region of the basal portion of the peristome, ×300. 22 and 23, showing the basal portions of two teeth; 24 and 25, showing the same, together with the basilar membrane; 26, showing the basilar membrane only.

on right, 23), beyond which the transverse ridges project for only a short distance (FIG. 24, 25).

The thinner deposits of thickening formed by the inner peristomial cells gradually increase in width toward the base until they finally meet and coalesce at the radial walls between the two rows of cells (FIG. 17, 22, 23). The vestiges of the radial walls form a zigzag longitudinal line on the inner surface of the tooth, and not on the outside as in the Diplolepideae. This line is of course much shorter than in *Funaria hygrometrica* and *Mnium hornum*, in which the teeth are not divided into branches. No

transverse ridges are developed in the inner peristomial layer, but the vestiges of the walls remain visible as fine lines.

When the strands of thickening have reached their full size, the spicules of cell wall substance are deposited in immense number over the entire surface (FIG. 17–19, 21–25). Those formed by the outer cells are considerably longer than those formed by the inner cells, but all are exceedingly minute.

The cells which form the basilar membrane of the peristome acquire thick walls also, but the deposits of thickening differ from those which form the teeth. This is especially true of the outer peristomial layer where the thickening extends almost evenly over the inner walls, the radial walls, and the transverse walls but leaves large pits on the outer walls (FIG. 25, 26). In the inner peristomial layer the thickening is less pronounced and forms a continuous layer over the outer wall. Throughout this portion of the peristome the surface of the thickening remains smooth, no spicules being developed. The basilar membrane lies just within the large cells of the annulus (FIG. 25).

Soon after the spicules have been deposited upon the teeth the peristomial cells dry up, the thin parts of the walls shrivel away and disappear, and the teeth become free. In the basilar membrane the pits in the outer wall now appear as perforations. At the same time the operculum becomes separated, and the endothecial tissues disintegrate. The finer structure of the mature peristome and the hygroscopic movements which it executes are fully described by Steinbrinck ('97).

SUMMARY

The original amphithecium, showing eight cells in cross section, divides by periclinal walls into an inner and an outer layer.

The inner peristomial layer develops from the inner amphithecial layer, undergoing division by anticlinal walls until it is composed of twenty-four longitudinal rows of cells.

The outer peristomial layer develops from sixteen longitudinal rows of cells cut off by periclinal walls from the outer amphithecial layer, after its eight rows have been divided by anticlinal walls; the outer peristomial layer undergoes no further divisions by anticlinal walls.

Ridges of thickening, representing the future teeth, are laid down upon the periclinal walls between the two peristomial layers.

The cells of the peristomial layers form eight groups, each composed of two rows of cells of the outer layer and three rows of the inner layer. Each group gives rise to two teeth.

In the upper part of each group eight deposits of thickening are laid down in four strands, representing the four branches of the two teeth; in the lower part only two strands are formed, representing the basal undivided portions of the teeth.

In the outer peristomial layer thickenings are deposited also upon the transverse walls, representing the transverse ridges of the teeth.

In the undivided basal portion of each tooth a fine median longitudinal line on the inner surface represents the vestiges of the radial walls between two rows of peristomial cells.

In the basilar membrane the thickening of the walls in the outer peristomial layer is uniform except in case of the outer walls.

YALE UNIVERSITY.

LITERATURE CITED

Campbell, D. H. ('05). The structure and development of mosses and ferns. Second edition. New York.

Cavers, F. ('11). The inter-relationships of the Bryophyta. New Phytologist Reprint, No. 4.

Goebel, K. ('87). Outlines of classification and special morphology of plants. English translation. Oxford.

Kienitz-Gerloff, F. ('78). Untersuchungen über die Entwickelungsgeschichte der Laubmoos-Kapsel und die Embryo-Entwickelung einiger Polypodiaceen. Bot. Zeit. **36**: 33–64. *pl. 1–3.*

Kuntzen, H. ('12). Entwickelungsgeschichte des Sporogons von *Ceratodon purpureus.* Inaug.-Diss. Berlin.

Lantzius-Beninga, S. ('50). Beiträge zur Kenntniss des innern Baues der ausgewachsenen Mooskapsel, insbesondere des Peristomes. Nova Acta Kais. Leop.-Carol. Acad. **22**: 560–604. *pl. 56–66.*

Philibert, H. ('84). De l'importance du péristome pour les affinités naturelles des mousses. 2e article. Rev. Bryol. **11**: 65–72.

Philibert, H. ('88). Etudes sur le péristome. 7e article. Rev. Bryol. **15**: 6–12; 24–28; 37–44; 50–60; 65–69.

Steinbrinck, C. ('97). Der hygroscopische Mechanismus des Laubmoosperistoms. Flora **84** Ergänzungsbd.: 131–158.

Strasburger, E. ('02). Das botanische Practicum. 4te Auflage. Jena.

A note on the significance of sugar in the tubers of Solanum tuberosum

O. Butler

(with plate 2)

Sugar accumulates in the tubers of the potato during the rest period when they are subjected to low temperatures, and, at least this is the general opinion, at the time of germination. In other words sugar develops at a time when the various vitalistic phenomena are inactive and again when the life processes are proceeding actively.

I

During the rest period two factors influence the accumulation of sugar in the tubers of the potato: temperature and oxygen supply. Both these factors may act independently of one another or additively. I shall, however, for convenience, consider them separately.

Temperature

The effect of temperature on the accumulation of sugar in potato tubers was studied years ago by Müller-Thurgau* and, as the results he obtained have not been disproved, I will simply briefly review them, adding some data of my own in confirmation.

The belief is very tenaciously rooted in the popular mind that a potato becomes sweet only when it is frozen. A frozen potato never becomes sweet, moreover a potato does not freeze at 0° C., whence probably the origin of this notion. Potatoes, in fact, may be stored at 0° C. for a period of time without being injured, Müller-Thurgau having kept them at this temperature in some of his experiments for as long as one hundred days.

Taking 0° C., then, as the lowest temperature at which potatoes may be safely stored, Müller-Thurgau found that when the rates of sugar accumulation at 0° C., 3° C., and 6° C. were compared

* Müller-Thurgau, H. Ueber Zuckeranhäufung in Pflanzentheilen in Folge niederer Temperatur. Landw. Jahrb. 11: 757–828. 1882.

the following relation was approximately obtained, x being the amount of sugar formed at 0° C.

$$\frac{x}{3.6} \text{ at } 3° \text{ C. and } \frac{x}{7} \text{ at } 6° \text{ C.}$$

He also observed that individual potatoes of the same variety showed marked variations in the rapidity with which sugar accumulated in their tissues, but that if at 0° C. sugar accumulated in relatively small amount in the tubers of a given variety, then no accumulation would occur at 6° C., and conversely, if sugar was formed rapidly at 0° C., then a temperature of 8° C. would be usually necessary to effect the same result. At 10° C. sugar never accumulated.

The fact brought to light by Müller-Thurgau that different varieties of potatoes exhibit differences in the rapidity of sugar accumulation is readily confirmed, as the following table shows.

TABLE I

SUGAR ACCUMULATION IN DIFFERENT VARIETIES OF POTATOES STORED AT 1°–5° C. FOR 28 DAYS

	Percentage reducing sugar in potatoes*		
Variety of potato	At beginning of experiment	After 28 days	Daily increase
Triumph	0.59	0.97	+0.013
American Wonder	0.88	0.85	−0.001
Rural New Yorker	0.17	1.01	+0.03
Early Ohio	0.15	1.25	+0.039
Early Rose	0.42	0.86	+0.015
Red Alcohol	0.10	1.42	+0.047
Rusty Rose	0.43	1.10	+0.023
Blue Victor	0.53	1.22	+0.024
McCormick	0.43	1.04	+0.021

Müller-Thurgau found, taking his results for 3° C., as these more nearly approach the average temperature at which the potatoes were stored in the above experiment, that the daily increase during a period of 30 days was 0.021 per cent, results which are of the same order as those given in the above table.

According to Müller-Thurgau sugar does not accumulate in resting potatoes when they are stored at a temperature of 8° C.

* All the quantitative determinations given in this paper were kindly made for me by Mr. F. B. Morrison, Madison, Wis.

It would also appear as if potatoes stored at 8°–10° C. not only do not accumulate sugar but do not reconvert it into starch as occurs at higher temperatures (this is Müller-Thurgau's view of the matter), or dispose of it through respiratory activity. The amount of sugar present in the potatoes when they are placed in storage at this temperature suffers little change. This fact is clearly shown in the following table:

TABLE II

CHANGES IN SUGAR CONTENT OF DIFFERENT VARIETIES OF POTATOES AFTER STORAGE AT 8°–11° C. FOR 34 DAYS

	Percentage reducing sugar in potatoes		
Variety of potato	At beginning of experiment	At end of 34 days	Increase
Triumph	0.59	0.43	−0.16
American Wonder	0.88	0.65	−0.23
Rural New Yorker	0.17	0.24	+0.07
Early Ohio	0.15	0.16	+0.01
Early Rose	0.42	0.31	−0.11
Red Alcohol	0.10	0.17	+0.07
Rusty Rose	0.43	0.38	−0.05
Blue Victor	0.53	0.45	−0.08
McCormick	0.43	0.39	−0.04

When potatoes containing sugar are stored at 20° C. the sugar gradually disappears due to increased respiration and reconversion to starch (Müller-Thurgau). However, if the potatoes remain sufficiently long at 20° C. for germination to be initiated, an increase in the sugar content is liable to take place. The aberrant results in the following table may be accounted for on these grounds.

TABLE III

LOSS OF SUGAR IN POTATOES STORED AT 20° C. FOR 21 DAYS

	Percentage reducing sugar in potatoes		
Variety of potato	At beginning of experiment	At end of 21 days	Decrease
Triumph	0.59	0.22	−0.37
American Wonder	0.88	0.05	−0.83
Rural New Yorker	0.17	trace	−0.17
Early Ohio	0.15	0.08	−0.07
Early Rose	0.42	0.13	−0.29
Red Alcohol	0.10	0.15	+0.05
Rusty Rose	0.43	0.37	−0.06
Blue Victor	0.53	0.40	−0.13
McCormick	0.43	0.65	+0.22

When potatoes containing sugar are placed at 20° C. respiration immediately increases to a very marked extent, while in the case of similar potatoes containing none or only traces of sugar the increase is very slight. The respiration of the potatoes containing sugar, while very rapid at first, reaches a maximum in one and a half or two days, and then gradually decreases until it becomes equal to that of potatoes containing little or no sugar.

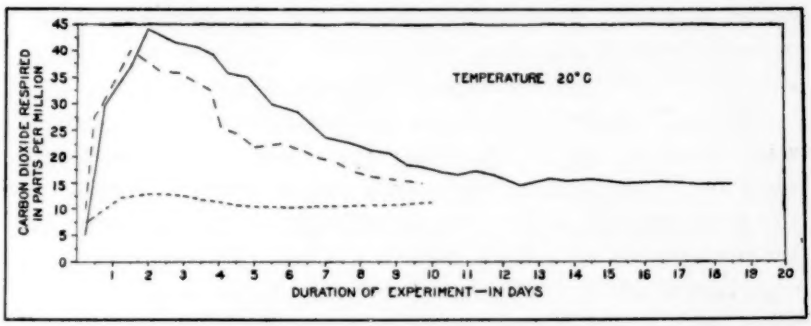

FIG. 1. (After Müller-Thurgau.) Respiration of potatoes containing different amounts of sugar at 20° C. Legend:

——— Respiration of 50 potatoes containing an average of 1.7814 per cent reducing sugar.

– – – – Respiration of 50 potatoes containing an average of 1.464 per cent reducing sugar.

- - - - - - Respiration of 50 potatoes containing none or only traces of reducing sugar.

The results obtained by Müller-Thurgau are very striking and are well illustrated in the above graph taken from his work. (FIG. 1.)

It is perfectly obvious that the respiratory activity of potatoes

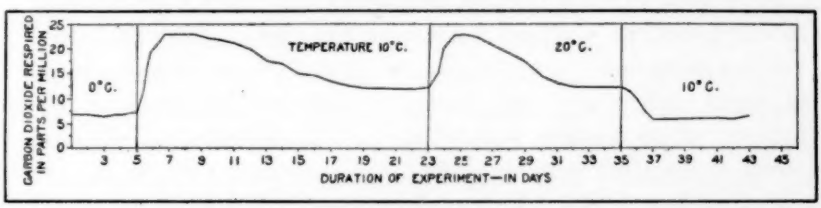

FIG. 2. (After Müller-Thurgau.) Influence of change of temperature on respiratory activity of potatoes initially rich in reducing sugar.

is more influenced by the presence of sugar than by temperature. Sugar is essentially a limiting factor. This is well illustrated in the second graph (FIG. 2), in which the respiratory activity of

potatoes stored at 0° C., then at 10° C., then at 20° C., and again at 10° C., is compared. It will be seen at once that when potatoes were placed at 10° C. respiration immediately increased, then fell gradually until the potatoes were placed at 20° C., when it rose again to the same maximum as before but decreased more rapidly and, after being placed at 10° C. again for a short while, became almost equal to what it had been when the potatoes were stored at 0° C. It should be noted that the experiments just recorded were begun after the potatoes had been kept for 28 days at 0° C., i. e., the potatoes used were rich in sugar.

Müller-Thurgau believed that when potatoes containing sugar were placed at 20° C. the sugar that disappeared was partly used up in respiration, and partly reconverted to starch, as the disappearance of the sugar could not be all accounted for by the amount of carbon dioxide exhaled. In performing his experiments Müller-Thurgau sliced his potatoes longitudinally, using one half for immediate analysis and the other for analysis at the end of the experiments. Under these conditions, even when the proper corrections for loss of weight due to evaporation are made, some of the sugar will undoubtedly go to the formation of the suber produced along the cut surface, and not unlikely, the increase in the percentage of starch obtained was due to the hydration of the cellulose that had been recently or was being laid down. The question, however, is deserving of further study.

OXYGEN

We have seen that during the rest period sugar may be made to accumulate in potatoes by storing the tubers at temperatures varying between 0° C. and 6° C., but that at 8°–10° C. the amount of sugar (when any was present) remained stationary. The relation of the oxygen supply to the accumulation of sugar in potatoes therefore may be studied conveniently at 8°–10° C. In the experiment which I have performed on this subject I used the Sir Walter Raleigh variety of potato and the tubers were placed in tubulated bell jars of the usual pattern:

Bell jar no. 1 contained 1,934 grams of potatoes, and the tubules were stopped with cotton, thus allowing a free diffusion of air.

Bell jar no. 2 contained 1,936 grams of potatoes and was connected with a water siphon by means of which approximately 8 per cent of the volume of the contained air was renewed daily.

Bell jar no. 3 contained 1,897 grams of potatoes and was connected with a water siphon by means of which approximately 0.8 per cent of the volume of the contained air was renewed daily.

Within a few days the air in all the bell jars became saturated with water vapor. The experiment was discontinued after 90 days, when the potatoes in the different bell jars were analyzed and found to contain sugar as follows:

Bell jar no. 1, 0.09 per cent sugar; bell jar no. 2, 0.22 per cent sugar; bell jar no. 3, 0.66 per cent sugar. The effect of reducing the oxygen supply on the accumulation of sugar in potatoes is, therefore, quite marked, though not nearly so notable as that of low temperature.

II

The view is very generally held that sugar accumulates in potatoes at the time of germination and that this accumulation is essential thereto. According to de Vries* sugar begins to appear in potatoes just prior to germination but before the buds show any signs of growth. Resting potatoes, he says, contain for the most part no sugar, its appearance indicating the initial stages of germination. The sugar first appears in the neighborhood of the eyes, more precisely in the parenchymatous tissue surrounding the bundles leading to them. At first present in small amounts, it soon increases in quantity, developing in all parts of the tubers. During their early period of growth the shoots contain starch but no sugar, though the tubers themselves are full of the latter, the larger amount being in the medulla, the smaller in the cortex. When the shoots are 8 mm. long sugar is found in them only in isolated spots, but somewhat later it is generally distributed, and this condition remains unchanged until they come through the soil.

The accumulation of sugar in potatoes has not, however, as regards germination, any particular physiological significance. As in the case of resting potatoes the amount of sugar found in

* Vries, H. de. Keimungsgeschichte der Kartoffelknollen. Landw. Jahrb. 7: 236. 1878.

germinating tubers is greatly influenced by the milieu in which germination takes place. Potatoes germinating at a relatively low temperature contain more sugar than potatoes germinating at relatively high temperatures, and potatoes germinating in soil contain more sugar than those germinating in a cellar. Again, the distribution of sugar in potatoes germinating in a cellar, for instance, is irregular. All these facts clearly indicate that the metabolism of germination is not concerned primarily in the distribution or degree of accumulation of sugar.* I will give a few examples in illustration.

Conditions favorable for germination are not necessarily favorable for the accumulation of sugar. For instance, on the 26th of April, 1912, I examined a number of Early Ohio potatoes, and they contained as a rule no sugar (PLATE 2, FIG. 6) though the sprouts were replete with it. A sample of these potatoes was placed in the ice compartment of an ice chest for 20 days, after which the potatoes composing it contained sugar as indicated in FIG. 2, 5. At the same time similar potatoes from the cellar contained sugar as indicated in FIG. 1 and 4. It is worthy of note that the potatoes stored in the ice chamber (FIG. 2, 5) resembled very closely the potatoes shown in FIG. 7, as regards distribution of the accumulated sugar. The distribution of sugar illustrated by FIG. 7 was rather common in stored potatoes during March, 1911, which stored potatoes had been at no time subjected to a temperature below 6° C. It is therefore clear that the low temperature had not induced irregularities in metabolism.

A glance at the plate will also force upon one the conclusion that the degree of germination has no effect upon the distribution of sugar. Neither is there any connection between presence or absence of sugar in the cortex with corresponding changes in the medulla. The medulla may contain sugar even in large amounts and the cortex give no reaction for it (FIG. 3, 7); again the cortex may contain sugar and the medulla be free from it (FIG. 1), though such cases appear to be rarer than the former; again the cortex

* The distribution of sugar in potatoes can be followed by boiling thin slices of the tubers in Fehling's solution for a few minutes, when traces of sugar will be indicated by a yellow coloration and an abundance by a red coloration, various shades of orange indicating intermediate amounts.

may contain sugar in large amounts near the suber and be almost free from it near the line of the medulla, which in turn may be more or less replete with it. Conditions illustrated in FIG. 2, 5, 9 are also not uncommon.

The distribution of sugar in germinating potatoes, considered with reference to the budding eyes, is also worthy of note. If one cuts longitudinal slices through potatoes in which the apical buds alone have sprouted he will find almost invariably that there is less sugar in the tubers immediately below the shoots than elsewhere. The conditions illustrated in FIG. 2, 5, 7, in which the medulla colors orange in Fehling's solution except for small areas beneath the insertion of the shoots and around the buds, may be also observed.

Qualitative tests having indicated that in germinating potatoes sugar occurred in less amounts near the apices than toward the bases and having also given indications that the bases were usually richer than the middle portions, I thought it would be well to have these results confirmed by quantitative analyses. The results obtained were as follows.

TABLE IV

DISTRIBUTION OF SUGAR IN GERMINATING POTATOES

Variety	Percentage reducing sugar in potatoes			Remarks
	Apical zone	Middle zone	Basal zone	
Early Ohio	0.12	.28	.59	Single tuber.
Early Ohio	None	.15	.42	Composite sample of 10 tubers.
Early Ohio	Trace	.35	.88	Single tuber.
Early Ohio	Trace	.46	.50	Single tuber.
Early Ohio	None	.35	.85	Single tuber.
Early Ohio	0.17	.59	.77	Single tuber.

TABLE IV confirms entirely the conclusions deducible from qualitative tests. Potatoes contain little or no sugar near their apices, sometimes nearly as much in their middle as in their basal portions, and sometimes much more towards the base than in the middle. It may be observed that Müller-Thurgau* found that resting potatoes were richer in sugar at the base than at the apex, and we have seen that this is generally true also of germinating potatoes.

* *Loc. cit.* p. 763.

The buds in potatoes tend to be more numerous around the apices, and one would expect, therefore, that during the rest period as well as at germination metabolic activity would be greater in the apical portions. One of the consequences of this increased activity in the apices of the resting potatoes would be a lesser accumulation of sugar and the difference in the percentage present, as one proceeded towards the base, would be the more noticeable, the less ready the translocation of the sugar from one part of the tubers to another: from the seats of lesser activity to the seat of greater activity. The data given in TABLE IV as well as the qualitative results illustrated in PLATE 2 show rather definitely, it seems to me, that there is little if any translocation from remote to budding parts even in germinating potatoes. Were the translocation of sugar a normal and necessary function in the metabolism of germination, its distribution would be more regular and constant; one would find a definite relation existing between cause and effect. The distribution of sugar (when present) in germinating and resting potatoes is not essentially different,* and it would seem, therefore, that its appearance in quantity just before or at germination should be ascribed, at least in part, to metabolic changes induced by another agent, or other agencies.

DURHAM, NEW HAMPSHIRE.

Description of plate 2

FIG. 1. Longitudinal section through Early Ohio from cellar, 16th May 1912.

FIG. 2. Longitudinal section through Early Ohio stored in ice chest 20 days, 16th May 1912. Compare with FIG. 1.

FIG. 3. Longitudinal section through Rural New Yorker from cellar, March 1911.

FIG. 4. Longitudinal section through Early Ohio from cellar, 16th May 1912.

FIG. 5. Longitudinal section through Early Ohio stored in ice chest 20 days, 16th May 1912. Compare with FIG. 1.

FIG. 6. Longitudinal section of Early Ohio from cellar, 26th April 1912.

FIG. 7. Longitudinal section of Early Ohio from cellar, 8th March 1911.

FIG. 8. Longitudinal section through Triumph from cellar, March 1911.

FIG. 9. Longitudinal section through Triumph from cellar, March 1911.

* It is well to point out that germinating potatoes as well as resting potatoes may contain no sugar (cf. FIG. 6).

Studies in the Agalinanae, a subtribe of the Rhinanthaceae *

FRANCIS W. PENNELL

I. NOMENCLATURE OF THE NEARCTIC GENERA

As here defined the Agalinanae constitute a subtribe of the Buchnereae and include a group of closely allied genera, distinguished from *Buchnera* and its nearer allies only by the normally developed two-celled anthers. These studies concern but a section of this group, all American save for one doubtful record from Madagascar, the genera listed by Von Wettstein in Die Natürlichen Pflanzenfamilien as *Esterhazya* Mikan, *Macranthera* Torr., *Seymeria* Pursh, *Silvia* Benth., and *Gerardia* Linn.

In this paper it is desired to place on a firm basis the nomenclature of the genera occurring in North America north of the Mexican Boundary. This has not proved as easy as anticipated, owing to a misunderstanding of a number of older genera, chief among which is that of *Gerardia* itself.

This paper divides itself naturally into two portions, a history of the genus *Gerardia* (Plumier) Linn., explaining the reason for its rejection as a genus of the Rhinanthaceae, and a history of the Rhinanthaceous genera proposed from time to time under which our species of this group must now be placed. This paper concludes with a summary of the nomenclature it is proposed to follow in these studies.

In 1703 the French traveller and botanist, Charles Plumier, a member of the religious order of the Minimi, published a work, "Nova Plantarum Americanarum Genera," containing descriptions of new genera observed during three voyages to America from 1689 to 1697. One of these is the new genus *Gerardia*.

In this work, a volume of 52 pages of Latin text and 40 plates, I find little mention of the portions of America visited, but in the preface to the same author's "Description des Plantes de L'Amérique" more information is given. He tells us that he went

* Contribution from the Botanical Laboratory of the University of Pennsylvania.

first as aid to M. Surian, charged with a commission from the King of France to the Isles Antilles, "to make search of all that Nature there produces most rare and most curious." During the nearly ten years spent in the West Indies, he described, he says, nearly six hundred different plants.

Gerardia is both described and figured. The description reads:—"Gerardia est plantae genus flore A monopetalo, personato, cujus labium superius surrectum est, subrotundum & emarginatum, inferius vero in tres partes divisum, media bifida. Ex calyce autem C surgit pistillum posticae floris parti B, ad instar clavi infixum, quod deinde abit in fructum D oblongum, gibbum, septo medio E, in duo loculamenta divisum, seminibusque foetum orbicularibus F." Then follows the note,—"Gerardiae unicam speciem vidi. Gerardia humilis, Bugulae foliis, Asphodeli radice."

The genus so founded by Plumier remained unaltered, and very little known, till the first edition of the Species Plantarum in 1753. Here Linnaeus took it up, and to Plumier's species which he named *Gerardia tuberosa*, added four others, *purpurea*, *flava*, *pedicularia* and *glutinosa*. It is evident, being the species adopted by Linnaeus from the original author of the genus, incidentally also being his first species listed, *Gerardia tuberosa* L. must be considered the type of the genus *Gerardia* (Plumier) Linnaeus.*

In addition to the striking feature indicated by the specific name, *tuberosa* is characterized by Linnaeus as "Gerardia foliis subovatis tomentosis repandis, longitudine caulis," points quite at variance from those of his other species with which the name *Gerardia* has come later to be exclusively associated. Yet Linnaeus' list of species, including *tuberosa*, with a few additions from time to time, was copied successively from author to author—by Buc'hoz (1778), Lamarck (1786), J. F. Gmelin (1791), etc., to Willdenow (1800), and Persoon (1807). A few authors of this period realized the incongruity of such treatment, and that logically the name *Gerardia* should apply to *tuberosa* alone.

* Though worked out independently by the writer, this same conclusion was reached a few months earlier by Dr. N. L. Britton. I am indebted to Dr. J. H. Barnhart for reviewing and confirming my determination of the type of *Gerardia*.

First among these was evidently Walter. In his Flora Caroliniana (1788) so far as our North American species are concerned, he relegates *Gerardia* to synonymy, and, not wishing to coin a new name, places *purpurea*, *flava* and *pedicularia* in one of his numerous genera called *Anonymos*.

In 1810 in treating *Gerardia* in Rees' Cyclopedia Sir James E. Smith, after listing first Linnaeus' *tuberosa*, remarks upon its identity being yet doubtful and suggests as a desideratum an examination of its fruit. Then he makes this statement. "Whatever might be the result of such examination this plant must be the true though it were the only *Gerardia*, and the rest in that case must have a new generic appellation and character." This is the first definite assignment of a type species for the genus.

As to the further history of *Gerardia tuberosa* L., after Sir J. E. Smith I find no writer retaining this plant in the Rhinanthaceae. In 1825 Sprengel interpreted it as a synonym of *Ruellia rupestris* Swartz, an Acanthaceous plant, whence in 1847 it was carried into the new genus *Stenandrium* of Nees, becoming a synonym of *Stenandrium rupestre* (Swartz) Nees. If this identification be correct *Stenandrium* Nees should become *Gerardia* (Plumier) L. Though antedating the erection of *Stenandrium* into a genus, such a change was actually made by Rafinesque in his Flora Telluriana in 1838, where *Gerardia tuberosa* L., *G. rupestris* (Swartz) Raf., and *G. scabrosa* (Swartz) Raf. are cited.

In 1835 Bentham in his "Synopsis of the Gerardieae" discusses the past history quite fully, definitely relegates *G. tuberosa* L. to the Acanthaceae, and endorses the earlier selection, practically made by Sprengel, of *G. purpurea* L. as the type. This view has been mostly followed till the present day.

If *Gerardia* is properly an Acanthaceous genus what name is to be applied to our familiar North American species commonly so called?

Of the Linnaean species of this genus to be retained in the Rhinanthaceae three were North American and one Chinese, the latter however not proving a near ally of the others. Species continued to be added from both hemispheres till as late as 1846 when in DeCandolle's Prodromus Bentham finally separated the

series into a number of definitely restricted New World and Old World genera. The Old World genera differ from the New in more points than were realized at that time, so may be definitely dismissed from the present discussion.

After Linnaeus' time the first new names proposed were in 1788 Walter's two genera both named *Anonymos*. These were well characterized; the one might be typified by *Gerardia purpurea* L., the other by a new species *Anonymos cassioides* Walt. Of course the name—or confession of the lack of a name—*Anonymos*, has no value in nomenclature.

In 1791 J. F. Gmelin, reviewing Walter's work, returned his first *Anonymos* to *Gerardia*, but maintained his second *Anonymos* as a new genus *Afzelia*. *Anonymos cassioides* Walt. became *Afzelia cassioides* (Walt.) J. F. Gmel. This genus also was by later authors returned to *Gerardia*, and when in 1814 Pursh became convinced of its generic distinctness, finding the name *Afzelia* meantime applied to a genus of the Caesalpiniaceae, he renamed the genus *Seymeria*. *Afzelia* J. F. Gmel. was restored by Kuntze in 1891. The genus to which this name is applied is a definite, natural group of Mexico and the southern coastal plain region of the United States.

The next generic description in this group is in 1794 that of *Virgularia* described by Ruiz and Pavon from Peru, and based upon their *V. lanceolata*, the specific description of which did not appear till 1798. Though loath with limited material to enter upon any discussion of the South American species of this group, it is necessary to attempt to decide whether this genus can be distinguished from those later proposed to include our North American species.

In the differential characters pointed out by Ruiz and Pavon I find, I confess, little that is convincing. The description of a bifid stigma is surely remarkable, but as no later observer has recorded such a structure in this or in any other South American species of this group, there is doubtless here some error. Also the characters depended upon by Martius (1829) have been shown by Bentham (1835) to be untrustworthy. Since 1835 the name *Virgularia* has been considered a synonym of *Gerardia* L. Yet an inspection of the species of *Virgularia* will, I think, show us

sufficient points of contrast. The material before me is all Bolivian,* but may be safely assigned to this genus.

In *Virgularia* the plant is shrubby, and for our purpose is best distinguished by its tubular, fleshy corolla, mostly red (or some allied shade), after flowering somewhat persistent, shriveling and only tardily falling. These characters appear again, at least in greater part, in the Brazilian *Esterhazya* Mikan, and in our North American *Macranthera* Torr. (to be mentioned later), and seem to indicate a sharp distinction between these three genera and the remainder. *Virgularia* is to be held as a natural, well-marked genus of western South America.

The remainder of this paper will deal strictly with the species of the United States, no other generic name having been proposed from Tropical or South America which can affect the nomenclature of our species. Yet it must be remembered that *a* or *the* great center of this group lies in South America, and no complete understanding of the inter-relationship of the whole can be gained till the species there are studied. Such study is deferred.

The next name that could concern us is in a work descriptive of fruits, *Chytra* Gaertn. fil., 1805. As only the fruit is shown, and that does not seem conclusive—and as no native country whatever is given—this plant may be left permanently as unidentifiable. Such a solution is suggested by Gaertner's specific name *anomala*. Yet it must be recognized that his figure shows a decided resemblance to a "Gerardia" capsule.

In 1819 Rafinesque descrided a yellow-flowered, coarse, lanceolate-leaved plant from Western Kentucky, under a new genus, *Dasistoma*. His description is clear and good, and leaves no doubt that his plant was the one described one year previously (1818) as *Seymeria macrophylla* Nutt. Rafinesque speaks of a short corolla-tube, rotate, 5-lobed limb, 4 nearly equa stamens, short filaments, glabrous anthers, short, cylindrical style, thick, obtuse stigma,—excellent diagnostic characters for *macrophylla*, but all impossible for *Dasistoma* (spelled *Dasystoma*) as taken up in 1846 by Bentham, and followed in later works. *Dasistoma* was based upon *D. aurea* Raf. (1819), antedated by *Seymeria macrophylla* Nutt. (1818), so the combination becomes

*Bang 188, 730, 2530, 2854; Buchtien 129, 789; Rusby 1077, 1078, 1080, 1081.

D. macrophylla (Nutt.) Raf. (1837). *Seymeria macrophylla* Nutt. was in 1846 made the basis of a section Brachygyne Benth., which in 1903 was raised to a genus *Brachygyne* (Benth.) Small, identical with the older *Dasistoma* Raf. The genus is monotypic.

In 1834 Nuttall described a new genus *Conradia* based upon a large and showy plant, specimens of which he had seen in the herbarium of the Philadelphia Academy of Natural Sciences. His name *Conradia* was antedated by *Conradia* Raf. (1825), and by *Conradia* Mart. (1829), so in 1835, in the account of the plants of Drummond's collection, the name was changed to *Macranthera*. Though this series of articles in the Companion to the Botanical Magazine was mostly the work of the editor, Sir W. J. Hooker, Bentham is to be credited for this genus. In the original description Le Conte's and Bentham's names were both cited after the genus, but in a later article during the same year Bentham tells us *Macranthera* was a manuscript name used by Dr. Torrey in communicating the plant to Dr. Lindley. Doubtless because the collector of the plant in Torrey's herbarium (however described two years later as a second species) Le Conte was mentioned, so with Bentham's explanation Torrey's name may be connected with the plant in question. *Conradia* Nutt. was based upon *C. fuschioides* Nutt., the spelling of which was corrected to *fuchsioides* in the combination *Macranthera fuchsioides* (Nutt.) Benth. However, as this plant had been previously described by William Bartram in his Travels (1791) as *Gerardia flammea*, this species must become **Macranthera flammea** (Bartram) Pennell comb. nov.

In 1835 Bentham reviewed this tribe, adding no new generic names, but systematizing and coördinating the whole, and with another revision in 1846 giving the outline which has been mostly adopted since.

In 1837 Rafinesque undertook the special elaboration of this group in his New Flora of America, adding several new generic names, not giving us a very satisfactory or coördinated treatment, yet showing nevertheless a surprising insight into the group. As I have already had to refer to several of his names, as he proposed a number of genera which must be adopted, and as since his time no new genera have been proposed which he had not already defined, it will be well to go carefully over his treatment.

In the first place, as already recounted, he definitely carried out Sir J. E. Smith's suggestion, and transferred *Gerardia* as a valid genus to the Acanthaceae.

Our Rhinanthaceous species, *Gerardia* of authors and its near allies, he placed in about eight genera, two of which, *Macranthera* "Torr." Benth. and *Seymeria* Pursh, were adopted from other authors, and one, *Dasistoma*, was, as shown above, an earlier genus of his own.

His first genus was *Aureolaria*, created to include the large, perennial, broad-leaved species, and based upon the current interpretation of *Gerardia flava* L. As his *Dasistoma* has been wrongly applied to this group, this first name becomes the correct one for these plants. As *Gerardia flava* L., both by description and the specimen in the Linnaean herbarium, is synonymous with *Rhinanthus virginicus* L., the type-species of the present genus—our pubescent eastern plant—must be known by the name here given it, *Aureolaria villosa* Raf.

His second genus, doubtfully considered distinct from the last, is nearly as uncertain to the present reviewer. *Panctenis* was based upon *Gerardia pedicularia* L. This species and a few close allies agree with *Aureolaria* in broad leaves, yellow flowers, and awned anthers, but their points of disagreement are equally striking. The annual habit of *Panctenis*, its corolla pubescent without, its wingless seeds, constitute several points of difference. I prefer to treat it as a subgenus of *Aureolaria*. The combination *Aureolaria pedicularia* (L.) was made as a variant by Rafinesque.

His third genus, *Agalinis*, in point of numbers is the most important of all. Based upon *Agalinis palustris* Raf., this genus was designed to include all the slender, narrow-leaved, purple-flowered plants, which Bentham later (1846) has treated as his section Eugerardia, and recent writers have come to consider true *Gerardia*. This is a large genus of both North and South America, falling into a number of well-marked subgenera. The type of the genus, *Agalinis palustris* Raf., is the prevalent plant of moist ground, near marshes, from New England to Carolina, Rafinesque correctly interpreting *Gerardia purpurea* L. as intended to include all the purple species. However *G. purpurea* L. is to be typified by the only Linnaean citation with a figure, Plukenet's "Digitalis

virginiana rubra, foliis et facie antirrhini vulgaris," which is unquestionably the current interpretation of the species. *Agalinis palustris* Raf. becomes **Agalinis purpurea** (L.) Pennell comb. nov.

In *Tomanthera* he placed, as *T. lanceolata*, a plant in his herbarium collected in New Jersey by Dr. Cleaver, and cited the species as occurring in Pennsylvania and Carolina. His plant appears to have been undoubtedly *Gerardia auriculata* Michx., described in 1803 from the prairies of Illinois, his specimen being quite small for the species. Possibly the leaves were abnormally entire, or perhaps they were lobed at base and this feature overlooked. His notice of the rarity of the plant is interesting, agreeing with Dr. Darlington and more recent observers of its sporadic occurrence in the East. With *T. lanceolata* he correctly but doubtfully associated *Gerardia auriculata* Michx., though incorrectly as a distinct species. The genus *Tomanthera*, including two species as now understood, is accordingly based upon *T. auriculata* (Michx.) Raf. In 1835 Bentham had based his section Otophylla upon *Gerardia auriculata* Michx., in 1846 raising this to a genus of the same name. *Otophylla* Benth. (1846) therefore becomes a synonym of *Tomanthera* Raf. (1837).

His *Dasistoma* of 1819 was here continued, and, as above shown, *Seymeria macrophylla* Nutt. was identified with it, though as a distinct species. The name *Dasistoma* was here spelled *Dasistema*, and *D. aurea* of 1819 was changed to *D. auriculata*.

Seymeria he adopted unaltered from Pursh.

A genus *Ovostima* was described based upon one species *O. petiolata* from Florida or Alabama. From the description of the plant, the large smooth corolla, bicuspidate anthers, etc., I believe the plant to have been an *Aureolaria*, though the description of the flower as white is surprising. In *Aureolaria* the corolla is fleshy and blackens in drying, not thin and apparently white or very pale ochroleucous as described for *Ovostima*. The plant is left as of doubtful identity.

Macranthera was adopted from Bentham, and for the two species that had then been published, *M. fuchsioides* (Nutt.) Benth. and *M. Lecontei* Torr., he proposed two additional generic names, *Toxopus* and *Tomilix*. As *M. Lecontei* Torr. appears not to have been published till 1837 there is sufficient evidence that

the date on the title page, 1836, is not the date of this volume of Rafinesque's work. *Macranthera fuchsioides* (Nutt.) was yet again described by Rafinesque as *Russelia flammea* based upon Bartram's incidental description of the plant in his Travels as *Gerardia flammea*, and the suggestion made that it is possibly to be considered as a new genus *Flamaria*.

An earlier genus of Rafinesque's, *Pagesia* (1817), reproduced in the New Flora, has been attributed by various authors to *Dasystoma* or *Gerardia*, but certainly does not belong here. Can *Pagesia leucantha* Raf. be identified with *Mecardonia acuminata* (Walt.) Small?

Finally the genus *Dasanthera* Raf., under which in the New Flora he placed *Gerardia cuneifolia* Pursh and *G. fruticosa* Pursh, has no close affinity with this group, nor even harmony within itself. One species, *G. cuneifolia*, had been already identified by Bentham (1835) as *Gratiola acuminata* Walt. (cited as Ell.), so by synonomy would be *Mecardonia acuminata* (Walt.) Small; the other, *G. fruticosa*, by the same author in 1835 was considered a *Pentstemon*, in 1846 as his *P. Lewisii*, a name which Greene (1892) has changed to *P. fruticosus* (Pursh).

Since 1836 there have been but two new generic names proposed for Nearctic species of this group, *Otophylla* Benth. (1846), and *Brachygyne* (Benth.) Small (1903), both of which are antedated by names of Rafinesque's. The present writer has none to add to the sufficient number already published.

A summary of the Nearctic genera of this group, with the type species for each, would be:

AFZELIA J. F. Gmel.; Linn. Syst. Nat. ed. 13. 927. 1791.
—*Anonymos cassioides* Walt.

—*Seymeria* Pursh, Fl. Amer. Sept. 736. 1814.
—*Anonymos cassioides* Walt.

DASISTOMA Raf. Journ. de Phys. **89**: 99. 1819.
—*Dasistoma aurea* Raf. (= *Seymeria macrophylla* Nutt.).

—*Brachygyne* (Benth.) Small, Fl. S. E. U. S. 1073. 1903.
—*Seymeria macrophylla* Nutt.

MACRANTHERA "Torr."; Benth. in Hook. Comp. Bot. Mag. **1**: 174. 1835.

—*Conradia fuchsioides* Nutt. (= *Gerardia flammea* Bartram).

—*Conradia* Nutt. Jour. Acad. Nat. Sci. Phila. **7**: 88. 1834 [not *Conradia* Raf. Neog. 3. 1825; nor *Conradia* Mart. Nov. Gen. et Sp. **3**: 38. 1829].

—*Conradia fuchsioides* Nutt.

—*Flamaria* Raf. New Flor. Amer. **2**: 71. 1837.

—*Gerardia flammea* Bartram.

—*Toxopus* Raf. New Flor. Amer. **2**: 71. 1837.

—*Macranthera Lecontei* Torr.

—*Tomilix* Raf. New Flor. Amer. **2**: 72. 1837.

—*Conradia fuchsioides* Nutt.

AUREOLARIA Raf. New Flor. Amer. **2**: 58. 1837.

—*Aureolaria villosa* Raf.

—*Panctenis* Raf. New Flor. Amer. **2**: 60. 1837.

—*Gerardia pedicularia* L.

(?)—*Ovostima* Raf. New Flor. Amer. **2**: 70. 1837.

—*Ovostima petiolata* Raf.

AGALINIS Raf. New Flor. Amer. **2**: 61. 1837.

—*Agalinis palustris* Raf. (= *Gerardia purpurea* L.).

TOMANTHERA Raf. New Flor. Amer. **2**: 65. 1837.

—*Tomanthera lanceolata* Raf. (= *Gerardia auriculata* Michx.).

—*Otophylla* Benth. in DC. Prodr. **10**: 512. 1846.

—*Gerardia auriculata* Michx.

UNIVERSITY OF PENNSYLVANIA.

LITERATURE CITED

Bartram, William. Travels through North and South Carolina, Georgia, east and west Florida, etc., 412. Philadelphia, 1791.

Bentham, George. Synopsis of the Gerardieae, a tribe of the Scrophulariaceae. Hook. Comp. Bot. Mag. **1**: 198–212. 1835.

Bentham, George. Scrophulariaceae, in DeCandolle, Prodromus **10**: 511–521. 1847.

Buc'hoz, P. J. *Gerardia.* in Histoire Universelle du Regne Végétale **9**: 97–99. 1778.

Darlington, William. Flora Cestrica, 365. West Chester, Pa. 1837.

Gaertner, C. F. De Fructibus et Seminibus Plantarum **3**: 184. *pl. 214, fig. 4.* Stuttgart, 1805.

Gmelin, J. F. Linné, Systema Naturae, ed. 13. **2**: 927–928. Leipzig, 1791.

Greene, E. L. Pittonia **2**: 239. Berkeley, Calif. 1892.

Hooker, W. J. Notice concerning the late Mr. Drummond's collections, made chiefly in the southern and western parts of the United States. Hook. Comp. Bot. Mag. **1**: 174. 1835.

Kuntze, Otto. Revisio Generum Plantarum **1**: 457. 1891.

Lamarck, J. B. A. P. M. Encyclopédie méthodique, Botanique **2**: 688. Paris, 1786.

Linnaeus, Carolus. Species Plantarum 610. Stockholm, 1753.

Martius, C. F. P. de. Nova Genera et Species Plantarum, quas in itinere per Brasiliam annis 1817–1820 jussu et auspiciis Maximiliani Josephi I Bavariae regis augustissimi suscepto **3**: 5–11. Munich, 1829.

Michaux, André. Flora Boreali-Americana **2**: 20. Paris, 1803.

Nees von Esenbeck, C. G. Acanthaceae, in DeCandolle, Prodromus **11**: 283. 1847.

Nuttall, Thomas. The genera of North American plants, and a catalogue of the species, to the year 1817 **2**: 49. Philadelphia, 1818.

Nuttall, Thomas. A description of some of the rarer little known plants indigenous to the United States, from the dried specimens in the herbarium of the Academy of Natural Sciences in Philadelphia. Jour. Acad. Nat. Sci. Phila. **7**: 88. 1834.

Persoon, C. H. Synopsis Plantarum **2**: 154. Paris, 1807.

Plukenet, Leonard. Almagesti Botanici Mantissa 65. *pl. 388, fig. 1.* 1700.

Plumier, Charles. Nova Plantarum Americanarum Genera 31. *pl. 12.* Paris, 1703.

Pursh, Frederick. Flora Americae Septentrionalis 736. London, 1814.

Rafinesque-Schmaltz, C. S. Florula Ludoviciana 48. New York, 1817.

Rafinesque-Schmaltz, C. S. Prodrome des noveaux genres de plantes observés en 1817 et 1818 dans l'intérieur des États-Unis d'Amérique. Jour. de Phys. Chim. et Hist. Nat. **89**: 99. 1819.

Rafinesque-Schmaltz, C. S. New flora and botany of North America **2**: 58–72. Philadelphia, 1837.*

Rafinesque-Schmaltz, C. S. Flora Telluriana **4**: 67. Philadelphia, 1838.*

* For dates of publication of separate parts of these see Barnhart, Torreya **7**: 177–182. 1907.

Ruiz, L. H., & Pavon, J. Florae Peruvianae et Chilensis Prodromus 92. *pl. 19.* Madrid, 1794.

Ruiz, L. H., & Pavon, J. Systema vegetabilium Florae Peruvianae et Chilensis 161. Barcelona, 1798.

Small, J. K. Flora of the southeastern United States 1073, 1338. New York, 1903.

Smith, J. E. *Gerardia*, in Rees' Cyclopedia. 1810.*

Sprengel, Kurt. Linnaeus, Systema Vegetabilium, ed. 16. **2**: 806–808, 825. Göttingen, 1825.

Torrey, John. An account of several new genera and species of North American plants. Ann. Lyc. Nat. Hist. New York **4**: 80. *pl. 4.* 1837.†

Walter, Thomas. Flora Caroliniana 169–170. London, 1788.

Wettstein, R. v. Scrophulariaceae, in Engler & Prantl, Die Natürlichen Pflanzenfamilien 4^{3b}: 92–93. Leipzig, 1891.

Willdenow, C. L. Linnaeus, Species Plantarum, ed. 4. **3**: 221. Berlin, 1800.

* I am indebted to Dr. J. H. Barnhart for the date of this volume.

† No date with paper, cited as 1837 in Index Kewensis.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1911–1913)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

Arthur, J. C. A new weed exterminator. Science II. **37**: 19. 3 Ja 1913.

Banker, H. J. Type studies in the *Hydnaceae*—III. The genus *Sarcodon*. Mycologia **5**: 12–17. Ja 1913.

Includes *Sarcodon radicatus*, *S. Murrillii*, *S. fumosus*, and *S. roseolus*, spp. nov.

Ball, C. R. The kaoliangs: a new group of grain sorghums. U. S. Dept. Agr. Plant Ind. Bull. 253: 5–64. *pl. 1, 2 + f. 1–15*. 11 Ja 1913.

Bartlett, H. H. The purpling chromogen of a Hawaiian *Dioscorea*. U. S. Dept. Agr. Plant Ind. Bull. 264: 5–19. *pl. 1 + f. 1*. 8 Ja 1913.

Bates, J. M. *Ophioglossum vulgatum* in Nebraska. Fern Bull. **20**: 67. [Ja 1913.]

Berger, A. *Opuntia Ficus barbarica* Berger nom. nov. Monats. Kakteenk. **22**: 181. 15 D 1912.

Bessey, C. E. Some of the next steps in botanical science. Science II. **37**: 1–13. 3 Ja 1913.

Bitter, G. *Solana* nova vel minus cognita. V. Repert. Sp. Nov. **11**: 349–394. 15 D 1912; VI. Repert. Sp. Nov. **11**: 431–473. 31 D 1912.

Includes 17 new species and several new varieties in the section *Tuberarium* of Bitter, and 6 new species in the section *Polybotryon*.

Brain, C. K. A list of fungi of Cedar Point. Ohio Nat. **13**: 25–36. D 1912.

Brannon, M. A. Factors influencing the flora of Devils Lake, North Dakota. Internat. Rev. **4**: 291–299. 1911.

Britton, E. G. *Ditrichum rhynchostegium* Kindb. Bryologist **16**: 8. Ja 1913.

Campbell, D. H. Some impressions of the flora of Guiana and Trinidad. Pop. Sci. Mo. **82**: 19–32. *f. 1–3.* Ja 1913.

Chambers, C. O. The relation of algae to dissolved oxygen and carbon-dioxide, with special reference to carbohydrates. Ann. Rep. Missouri Bot. Gard. **23**: 171–207. 1912.

Chodat, R. A grain of wheat. Pop. Sci. Mo. **82**: 33–45. Ja 1913.

Clute, W. N. *Polypodium* or *Xiphiopteris*? Fern Bull. **20**: 65–67. [Ja 1913.] [Illust.]

Clute, W. N. Priority and fern names. Fern Bull. **20**: 68–73. [Ja 1913.]

[Clute, W. N.] Pteridographia. Fern Bull. **20**: 74–80. [Ja 1913.]

Includes notes on: Ferns in bottles; New stations for Florida ferns; Additional fern pests; Number of articles on ferns; A new *Equisetum;* New southwestern ferns; Death of James Goldie; Two new fern sports; Crested Christmas fern; Bermuda ferns; Ferns as weeds.

Clute, W. N. Rare forms of fernworts—XXIII. Who can name this fern? Fern Bull. **20**: 73, 74. [Ja 1913.] [Illust.]

Collins, G. N. Heredity of a maize variation. U. S. Dept. Agr. Plant Ind. Bull. 272: 5–23. *pl. 1 + f. 1.* 21 Ja 1913.

Conard, H. S. Revegetation of a denuded area. Bot. Gaz. **55**: 80–84. *f. 1, 2.* 15 Ja 1913.

Cook, O. F. Heredity and cotton breeding. U. S. Dept. Agr. Plant Ind. Bull. 256: 5–113. *pl. 1–6 + f. 1–19.* 13 Ja 1913.

Cook, O. F. Morphology of cotton branches. U. S. Dept. Agr. Plant Ind. Circ. 109: 11–16. 4 Ja 1913.

Cooper, W. S. The climax forest of Isle Royale, Lake Superior, and its development. I. Bot. Gaz. **55**: 1–44. *f. 1–14 + map.* 15 Ja 1913.

Cooper, W. S. A list of mosses collected upon Isle Royale, Lake Superior. Bryologist **16**: 3–8. Ja 1913.

Dachnowski, A. Peat deposits of Ohio: their origin, formation, and uses. Ohio Geol. Surv. Bull. IV. 16: 1–424. *pl. 1–8 + f. 1–29.* Ap 1912.

Darbishire, O. V. The lichens of the Swedish Antarctic Expedition. Wiss. Ergeb. Schwed. Südpolar-Exp. 4^{11}: 1–73. *pl. 1–3 + f. 1.* Stockholm. 1912.

Davis, B. M. Mutations in *Oenothera biennis* L.? Am. Nat. **47**: 116–121. F 1913.

Durand, E. J. The genus *Keithia*. Mycologia **5**: 6–11. *pl. 81.* Ja 1913.

Includes *Keithia thujina* sp. nov.

Farlow, W. G. The change from the old to the new botany in the United States. Science II. **37**: 79–86. 17 Ja 1913.

Fernow, B. E., *and others.* Forest conditions of Nova Scotia. i–xi + 1–93. Ottawa. 1912. [Illust. + maps.]

Published by the Commission of Conservation, Canada.

Gainey, P. L. The effect of toluol and CS_2 upon the micro-flora and fauna of the soil. Ann. Rep. Missouri Bot. Gard. **23**: 147–169. 1912.

Gates, R. R. *Oenothera* and climate. Science II. **37**: 155, 156. 24 Ja 1913.

Gross, H. *Polygonaceae* nonnullae novae. Bot. Jahrb. **49**: 340–348. 14 Ja 1913.

Includes *Polygonum uruguense* and *Muehlenbeckia Nummularia*, spp. nov. from South America.

Hallier, H. Über frühre Landbrücken, Pflanzen und Völkerwanderungen zwischen Australasien und Amerika. Mededeel. Rijks Herb. Leiden 13: 1–32. *f. 1, 2.* 16 D 1912.

Halsted, B. D., *and others.* Report of the botanical department. Ann. Rep. New Jersey Agr. Exp. Sta. **32**: 311–399. *pl. 1–31.* Ja 1912.

Harris, J. A. Biometric data on the inflorescence and fruit of *Crinum longifolium.* Ann. Rep. Missouri Bot. Gard. **23**: 75–99. 1912.

Hasse, H. E. Additions to the lichenflora of southern California. 8. Bryologist **16**: 1, 2. Ja 1913.

Includes *Dermatocarpon Zahlbruckneri* sp. nov.

Hicken, C. M. Nomenclatura botánica. *Ilex paraguayensis* ó *paraguariensis*? An. Soc. Cie. Argentina **73**: 360–362. Je 1912.

Holden, R. Ray tracheids in the *Coniferales.* Bot. Gaz. **55**: 56–65. *pl. 1, 2.* 15 Ja 1913.

House, H. D. Woody plants of western North Carolina, 1–34. Darmstadt. 1913.

Howe, C. D. Distribution and reproduction of the forest in relation to underlying rocks and soils. In Fernow, B. E., Forest conditions of Nova Scotia, 43–93. Ottawa. 1912. [Illust. + maps.]

Howe, R. H., Jr. A monograph of the North American *Usneaceae.* Ann. Rep. Missouri Bot. Gard. **23**: 133–146. *pl. 7.* 1912.

Jeffrey, E. C. The history, comparative anatomy, and evolution of the *Araucarioxylon* type. Proc. Am. Acad. Arts & Sci. **48**: 531–571. *pl. 1–8.* N 1912.

Jewett, H. S. *Plagiothecium geophilum* (Aust.) Grout. Bryologist **16**: 8, 9. Ja 1913.

Kearney, T. H. The wilting coefficient for plants in alkali soils. U. S. Dept. Agr. Plant Ind. Circ. 109: 17–25. 4 Ja 1913.

Kunkel, L. O. A study of the problem of water absorption. Ann. Rep. Missouri Bot. Gard. **23**: 26–40. 1912.
Includes experiments with cultures of *Monilia sitophila* (Mont.) Sacc.

Learn, C. D. Studies on *Pleurotus ostreatus* Jacqu. and *Pleurotus ulmarius* Bull. Ann. Myc. **10**: 542–556. *pl. 16–18.* 31 D 1912.

Lillie, R. S. The rôle of membranes in cell-processes. Pop. Sci. Mo. **82**: 132–152. *f. 1–3.* F 1913.

Lipman, C. B. Antagonism between anions as affecting ammonification in soils. Centralb. Bakt. Zweit. Abt. **36**: 382–394. *f. 1–3.* 11 Ja 1913.

Livingston, B. E. Adaptation in the living and non-living. Am. Nat. **47**: 72–82. F 1913.

Lloyd, C. G. The polyporoid types of Léveillé at Leiden. Letter No. 36. Mededeel. Rijks Herb. Leiden 9: 1–5. 15 N 1912.

Lloyd, C. G. The polyporoid types of Junghuhn preserved at Leiden. Letter No. 37. Mededeel. Rijks Herb. Leiden 10: 1–5. 15 N 1912.

Lloyd, F. E., & Ridgway, C. S. The behavior of the nectar gland in the cacti, with a note on the development of the trichomes and areolar cork. Plant World **15**: 145–156. *f. 1–13.* Jl 1912.

Lodge, C. A., & Smith, R. G. Influence of soil decoctions from sterilized and unsterilized soils upon bacterial growth. Ann. Rep. Massachusetts Agr. Exp. Sta. **24**: 126–134. Ja 1912.

Mackenzie, K. K. A new *Carex* from Alberta. Proc. Biol. Soc. Washington **25**: 51, 52. 19 Mr. 1912.
Carex atrosquama Mackenzie.

Mackenzie, K. K. Western allies of *Carex pennsylvanica.* Torreya **13**: 14–16. 8 Ja 1913.
Includes *Carex heliophila* sp. nov.

Manns, T. F. Two recent important cabbage diseases of Ohio. Ohio Agr. Exp. Sta. Bull. 228: 255–297. *f. 1–26.* 1911.

Maxon, W. R. The tree ferns of North America. Smithsonian Rep. **1911**: 463–491. *pl. 1–15.* 1912.

Metcalf, M. M. Adaptation through natural selection and orthogenesis. Am. Nat. **47**: 65–71. F 1913.

Meyer, R. *Echinocactus macrodiscus* Mart. Monats. Kakteenk. **22**: 179–181. 15 D 1912.

Murrill, W. A. The *Agaricaceae* of tropical North America—VI. Mycologia **5**: 18–36. Ja 1913.

Includes new species in *Gymnopilus* (14), *Crepidotus* (9), and *Pholiota* (5). Several new combinations are made.

Murrill, W. A. Illustrations of fungi—XIII. Mycologia **5**: 1–5. *pl. 80.* Ja 1913.

Includes *Gyroporus castaneus* (Bull.) Quél., *Ceriomyces auriporus* (Peck) Murrill, *Rostkovites granulatus* (L.) P. Karst., *R. subaureus* (Peck) Murrill, *C. subglabripes* (Peck) Murrill, and *C. bicolor* (Peck) Murrill.

Norton, J. B. S. Maryland weeds and other harmful plants. Ann. Rep. Maryland Agr. Exp. Sta. **25**: 1–71. *pl. 1–13.* 1912.

Norton, J. B. Methods used in breeding asparagus for rust resistance. U. S. Dept. Agr. Plant Ind. Bull. 263: 5–60. *pl. 1–18. f. 1–4.* 13 Ja 1913.

Norton, J. B. S., & White, T. H. Rose mildew. Ann. Rep. Maryland Agr. Exp. Sta. **25**: 73–80. *f. 1–6.* 1912.

Ohlweiler, W. W. The relation between the density of cell saps and the freezing points of leaves. Ann. Rep. Missouri Bot. Gard. **23**: 101–131. *pl. 6.* 1912.

Osterhout, W. J. V. The effect of anesthetics upon permeability. Science II. **37**: 111, 112. 17 Ja 1913.

Peltier, G. L. A consideration of the physiology and life history of a parasitic *Botrytis* on pepper and lettuce. Ann. Rep. Missouri Bot. Gard. **23**: 41–74. *pl. 1–5.* 1912.

Perkins, J. Beiträge zur Flora von Bolivia. Bot. Jahrb. **49**: 177–233. 14 Ja 1913.

Includes descriptions of 20 new species contributed by various authors. (Continued from p. 176. 27 Au 1912.)

Quehl, L. *Mamillaria Kunzeana* Bödeker et Quehl spec. nov. Monats. Kakteenk. **22**: 177, 178. 15 D 1912. [Illust.]

Rehm, H. *Ascomycetes* exs. fasc. 51. Ann. Myc. **10**: 535–541. 31 D 1912.

Includes *Valsa saccharina* Rehm sp. nov. from Canada. Specimens distributed as *Urnula Craterium* Fr. and *Venturia Cassandrae* Peck were obtained from Canada.

Safford, W. E. *Annona diversifolia*, a custard-apple of the Aztecs. Jour. Washington Acad. Sci. **2**: 118–125. *f. 1–4.* 4 Mr 1912.

Safford, W. E. *Pseudannona*, a new genus of *Annonaceae* from the Mascarene Islands: together with notes on *Artabotrys uncinatus* and its synonymy. Jour. Washington Acad. Sci. 3: 16–19. 4 Ja 1913.

Sammis, E. M. A vacation among the mosses. Torreya **13**: 1–13. *f. 1–5.* 8 Ja 1913.

Schaffner, J. H. New and rare plants added to the Ohio list in 1912. Ohio Nat. **13**: 36. D 1912.

Schreiner, O., & Lathrop, E. C. The chemistry of steam-heated soils. U. S. Dept. Agr. Bur. Soils. Bull. 89: 5–37. 6 N 1912.

Seckt, H. Cóntribución al conocimiento de la vegetación del noroeste de la República Argentina. An. Soc. Cie. Argentina **74**: 185–225. S 1912.

Shaw, J. K. Heredity, correlation and variation in garden peas. Ann. Rep. Massachusetts Agr. Exp. Sta. **24**: 82–101. Ja 1912.

Shaw, J. K. The effect of fertilizers on variation in corn and beans. Am. Nat. **47**: 57–64. *f. 1, 2.* Ja 1913.

Stockberger, W. W. A literary note on the law of germinal continuity. Am. Nat. **47**: 123–128. F 1913.

Smith, C. O. Further proof of the cause and infectiousness of crown gall. California Agr. Exp. Sta. Bull. 235: 531–557, *f. 1–28.* D 1912.

Smith, R. E., *and others.* Walnut culture in California. California Agr. Exp. Sta. Bull. 231: 119–398. *f. 1–96.* Au 1912.

Includes a study of the walnut organism, *Pseudomonas Juglandis* Pierce, and other diseases of the walnut.

Snow, L. M. Progressive and retrogressive changes in the plant associations of the Delaware coast. Bot. Gaz. **55**: 45–55. *f. 1–6.* 15 Ja 1913.

Stone, G. E. Report of the botanist. Ann. Rep. Massachusetts Agr. Exp. Sta. **24**: — [3–107.] Ja 1912. [Illust.]

Includes: Diseases more or less common during the year; Rust on *Vinca;* Bronzing of maple leaves; A notable elm tree; Frost cracks; Some observations on the growth of elm trees; The effects of positive and negative electrical charges on seeds and seedlings. Reprinted with separate pagination.

Stone, G. E., & Chapman, G. H. Electrical resistance of trees. Ann. Rep. Massachusetts Agr. Exp. Sta. **24**: 144–176. *f. 1–3.* Ja 1912.

Stone, R. E. The life history of *Ascochyta* on some leguminous plants. Ann. Myc. **10**: 564–592. *pl. 19, 20.* 31 D 1912.

Tidestrom, I. A new *Salicornia.* Proc. Biol. Soc. Washington **26**: 13, 14. 18 Ja 1913.

Salicornia utahensis Tidestrom.

Transeau, E. N. The life history of *Gloeotaenium.* Bot. Gaz. **55**: 66–73. *pl. 3.* 15 Ja 1913.

Visher, S. S. The biology of south-central South Dakota. South Dakota Geol. & Biol. Surv. Bull. 5: 61–130. *pl. 33–44.* Je 1912.

Weingart, [W.] *Cereus laevigatus* S.-D. var. *guatemalensis* Eichlam. Monats. Kakteenk. **22**: 182–185. 15 D 1912. [Illust.]